Potential repellents to prevent mountain beaver damage

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Mountain beaver (*Aplodontia rufa*) damage to trees in the Pacific Northwest is economically serious. At present, few strategies are available to control damage, and new chemical repellents are being sought. Samples of two preferred plants, Douglas fir (*Pseudotsuga menziesii*) and salal (*Galtheria shallon*), were treated with mink urine, coyote urine, *o*-aminoacetophenone, or denatonium benzoate and presented to mountain beavers. All treatments reduced clipping ($p < 0.05$) of salal, but mink and coyote urines were most effective. Mink and coyote urines were the only treatments to significantly reduce clipping ($p < 0.05$) of Douglas fir.

Keywords: *Aplodontia rufa*; denatonium benzoate; *o*-aminoacetophenone; predator odours; repellents

Mountain beavers hinder reforestation on >121 500 ha of otherwise highly productive land in the Pacific Northwest (Campbell and Evans, 1988). Although the most common form of damage is the cutting of seedlings, mountain beavers also girdle adult trees and crop branches (Borrecco and Anderson, 1980). Clipped seedlings often die and those trees that do survive generally show retarded growth and deformities.

Trapping, poisoning, and mechanical barriers are used to control damage by mountain beavers (Campbell and Evans, 1988). Habitat manipulation and the destruction of burrow systems are also used to displace animals. Each of these methods is costly and, with the exception of poisoning, each is difficult to implement on a large scale. New alternatives are needed, and chemical repellents are being sought (Feldhamer and Rochelle, 1982).

Big Game Repellent (IntAgra, Inc., Minneapolis, MN, USA), is the only repellent available for use against mountain beavers (D. L. Campbell, unpublished data). This formulation may soon be unavailable, as the manufacturer has petitioned the US Environmental Protection Agency to cancel the registration (US Environmental Protection Agency, 1993). The experiments described here were performed to evaluate the potential effectiveness of four candidate substances. Two were predator urines (mink, MU; coyote, CU) avoided by mountain beavers in laboratory tests (Epple *et al.*, 1993). There is evidence that predator odours are generally avoided by herbivorous species (Sullivan and Crump, 1986; Sullivan, Crump and Sullivan, 1988; Merkins, Harestad and Sullivan, 1991; Swihart, 1991). The third compound was *o*-aminoacetophenone (OAP), an effective repellent for mice (*Mus musculus*), rats (*Rattus norvegicus*), and voles (*Microtus ochrogaster*) (D. L. Nolte, unpublished data). The fourth substance was denatonium benzoate (DB), the putative repellent in products sold to repel deer (e.g. Ro-Pel, Atomergic Chemical Company, Farmingdale, NY, USA) and a principal ingredient in a potential repellent for mountain beavers (Anapel, Macfarlan-Smith Ltd, Edinburgh, UK). Water was used as a control.

Materials and methods

Subjects

Mountain beavers were captured in the Capitol State Forest in Grays Harbor County, ~20 miles (≈32.2 km) from the Denver Wildlife Research Center (DWRC) field station in Olympia, Washington. The trials were conducted at the DWRC Olympia Field Station in Olympia, WA, USA. Animals were individually housed in pens (3 × 3 m) with high walls and a roof that provided protection from precipitation and wind. A nest box was located in the centre of each pen. Throughout trials, animals were given free access to water and deer pellets (X-Cell Feed Company, Tacoma, WA, USA).

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Compounds

Hawthorne's mink and coyote urine were purchased from M & M Furs Company (Bridgewater, SD, USA). OAP (CAS no. 551–93–9) was obtained from Aldrich Chemical Company (Milwaukee, WI, USA) and DB (CAS no. 3734–33–6) was donated by Atomergic Chemicals (Farmingdale, NY, USA). OAP and DB were mixed with water to yield 1.0% (w/w) emulsions and solutions, respectively.

Vegetation

Two-year-old Douglas fir seedlings (~20 cm in length) were obtained from a nursery (Washington State Department of Natural Resources, Mike Webster Nursery, Olympia, WA, USA). Segments (25 cm) of salal plants were collected in the grounds of the DWRC Olympia Field Station. Each segment carried five leaves. On collection, individual stems of both species were placed in plastic aqua piks (Syndicate Sales Inc., Kokomo, IN, USA).

Four Douglas fir seedlings and four salal segments each were individually dipped in one of five treatments: (1) MU; (2) CU; (3) 1.0% emulsion of OAP; (4) 1.0% solution of DB, or (5) water (control). All samples were allowed to air dry before they were offered to the mountain beavers.

Procedure

Seven mountain beavers were each offered 20 treated Douglas fir seedlings. Seedlings from each of the five treatments were randomly located within four blocks. Treatments within blocks were placed in a row ~10 cm apart. Blocks were located along pen walls ~1.5 m apart. Treatment efficacy was evaluated by counting the number of clipped seedlings after 2 weeks.

Subsequently, a similar trial was conducted with salal. Eighteen mountain beavers (including the seven animals used in the above trial) were each given 20 treated salal segments (100 leaves) presented after treatment with candidate repellents as described above. Treatment efficacy was evaluated by counting the number of missing leaves after 48 h. One animal was eliminated from the study because it failed to meet study criteria of taking at least one leaf.

Analysis

Analysis of variance were used to assess treatment effects (Winer, 1971). Subsequent to the omnibus procedures, Tukey tests were used to isolate differences among means ($p < 0.05$).

Results

There were differences among treatments for both Douglas fir seedlings ($F = 4.6$; d.f. = 4, 30; $p = 0.0057$) and salal ($F = 30.795$; d.f. = 4, 80; $p < 0.0001$). Both predator urines significantly reduced clipping of fir seedlings relative to clipping of control seedlings (*Figure 1*). Neither OAP nor DB had repellent effects. For salal, all four candidate repellents reduced clipping, but the predator urines were significantly more effective than either OAP or DB (*Figure 2*).

Discussion and management implications

All treatments reduced damage by mountain beavers to salal in comparison to water-treated control plants. However, only mink urine and coyote urine significantly reduced clipping of Douglas fir seedlings by mountain beavers. Avoidance continued for at least 2 weeks, a relatively durable effect consistent with results collected for other rodent species. Woodchucks, for example, avoid marking fruit trees sprayed with bobcat urine for as long as 93 days, and continue to avoid bobcat urine even when exposed to the odour in consecutive years (Swihart, 1991).

Our results have clear practical implications that warrant additional tests. One implication is that predator urines could reduce damage by free-ranging mountain beavers to Douglas fir plantations. Second, because other rodents avoid burrows treated with predator odours (e.g. Sullivan *et al.*, 1988), it is conceivable that mountain beavers might avoid treated burrows and nests.

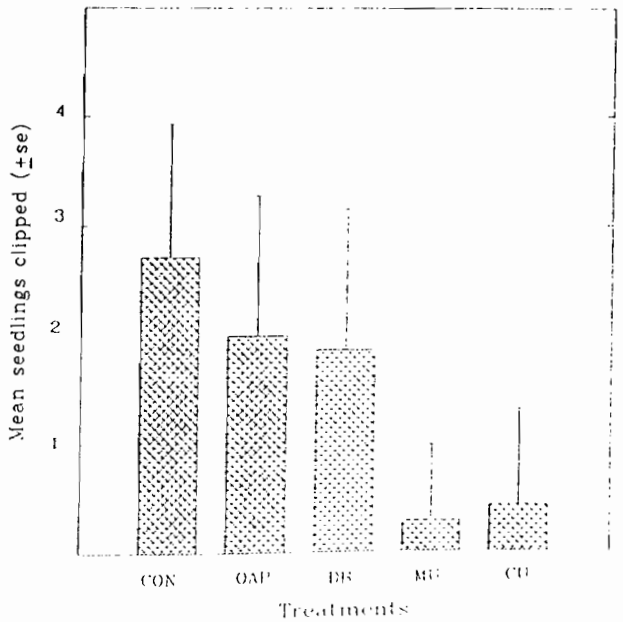

Figure 1. Mean number of Douglas fir seedlings treated with water (CON), *o*-aminoacetophenone (OAP), denatonium benzoate (DB), mink urine (MU) or coyote urine (CU) that were clipped by mountain beaver during a 2-week trial. Capped vertical bars represent standard errors of the means

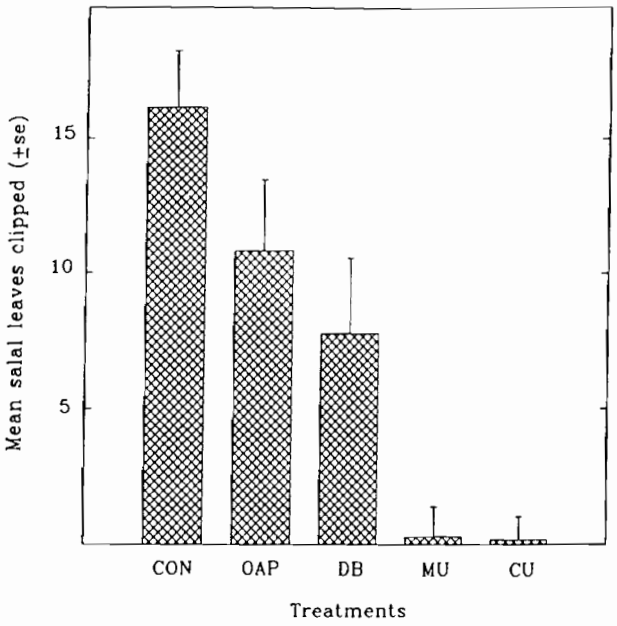

Figure 2. Mean number of salal leaves treated with water (CON), *o*-aminoacetophenone (OAP), denatonium benzoate (DB), mink urine (MU) or coyote urine (CU) that were clipped by mountain beaver during a 48 h trial. Capped vertical bars represent standard errors of the means

More generally, trees are long-lived, and rodent damage is difficult to prevent completely. No repellent is likely to provide total protection. Nevertheless, predator urines could reduce damage during periods when trees are most vulnerable. For example, during the first 2 years after transplantation, young seedlings (grown in nursery beds for 2 years) suffer a higher mortality loss than do older seedlings (grown in nursery beds for 3 years) (Borrecco and Anderson, 1980). In addition, non-lethal damage to young seedlings has a greater impact on their subsequent growth than it does on older seedlings. Repellents might be especially useful for the protection of young seedlings when they are first planted out, or during the seasons when damage is most likely to occur. At high elevations, for example, Douglas fir is predominantly damaged by mountain beavers during winter and spring when other forage is not readily available and the nutritional value of conifers is high (O'Brian, 1988).

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